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Effects of fluazifop-butyl on shoot growth and rhizome buds of *Elymus repens* (L.) Gould

J. P. N. R. CHANDRASENA* AND G. R. SAGAR *School of Plant Biology, University College of North Wales, Bangor LL57 2UW, U.K.*

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Summary: Résumé: Zusammenfassung

A series of glasshouse experiments was conducted to evaluate the activity of fluazifop-butyl, butyl 2-[4-(5-trifluoromethyl-2-pyridyloxy)phenoxy] propionate, against *Elymus repens*. Foliar applications of doses 0·25–1·0 kg ha^{-1} consistently gave better control than did soil applications. The most obvious phytotoxic symptoms were chlorosis and necrosis, beginning with the youngest leaves 5–6 days after spraying, which spread to all leaves within 2 weeks. Translocation was measured by defoliating plants at different times after spraying and assessing regrowth and by evaluating rhizome-bud viability. At low doses (0·125 and 0·25 kg ha^{-1}) translocation to rhizomes occurred mainly between 6 and 48 h. When fluazifop-butyl was sprayed at a dose range of 0·125–1·0 kg ha^{-1}, at least 90% of the rhizome buds had accumulated a lethal dose within 72 h of spraying. In another experiment, with a dose of 0·25 kg ha $^{-1}$, 31, 72 and 92% of rhizome buds were found to be non-viable when sampled 2, 24 and 48 h respectively after spraying. At 1·0 kg ha^{-1} all the buds had accumulated sufficient herbicide to prevent sprouting 48 h after spraying.

*Present address: Department of Botany, University of Colombo, P.O. Box 1490, Colombo-3, Sri Lanka.

Influence du fluazifop-butyl sur la croissance des pousses et des boutons de rhizome chez Elymus repens *(L.) Gould*

Une série d'expériences a été entreprise en serre pour évaluer l'activité du fluazifop-butyl, butyl 2-[4-(5-trifluoromethyl-2-pyridyloxy)phenoxy]propionate, contre *Elymus repens*. Des applications foliaires en doses de 0,25–1 kg ha^{-1} ont fourni une maitrise uniformément supérieure à celle des applications sur le sol. Les symptômes de phytotoxicité les plus frappantes étaient une chlorose et une nécrose qui se sont installées dans les feuilles les plus jeunes 5–6 jours après la pulvérisation, pour s'étendre dans deux semaines à toutes les feuilles. Pour mesurer la translocation de l'herbicide, les plantes ont été défeuillées à différentes époques après la pulvérisation dans le but d'en évaluer les repousses; la viabilité des boutons de rhizome a également été évaluée. Aux doses inférieures (0,125 et 0,25 kg ha^{-1}) le transport de l'herbicide dans les rhizomes s'est passé pour la plupart entre 6 et 48 h après la pulvérisation. Lorsque le fluazifop-butyl a été pulvérisé à des doses allant de 0,125 à 1 kg ha^{-1}, au moins 90% des boutons de rhizome avaient accumulé une dose mortelle déjà 72 h après la pulvérisation. Dans une autre expérience avec une dose de 0,25 kg ha^{-1}, 31, 72 et 92% des boutons de rhizome se sont trouvés non-viables lors d'un échantillonnage 2, 24 et 48 h respectivement après la pulvérisation. A une dose de 1 kg ha^{-1}, tous les boutons avaient accumulé, 48 h après la pulvérisation, assez d'herbicide pour les empêcher de pousser.

Auswirkungen von Fluazifop-butyl auf das Sprosswachstum und die Rhizomknospen des Elymus repens *(L.) Gould*

Eine Reihe von Gewächshausversuche wurde durchgeführt, um die Aktivität von Fluazifop-butyl, (Butyl 2-[4-(5-trifluoromethyl-2-pyridyl-

oxy)phenoxy] propionat) gegen *Elymus repens* festzustellen. Uber die Blätter ausgebrachte Dosen von 0,25–1 kg ha^{-1} wirkten ständig besser als Bodenapplikationen aus. Die auffallendsten Symptome der Phytotoxizität waren Chlorose und Nekrose, welche bei den jüngsten Blättern schon 5–6 Tage nach der Spritzung beobachtet wurden und binnen zwei Wochen sich zu allen Blättern ausgedehnt hatten. Die Translokation wurde gemessen, indem die Pflanzen zu verschiedenen Zeiten nach der Spritzung entlaubt wurden und das neue Wachstum festgestellt wurde. Auch die Keimfähigkeit der Rhizomknospen wurde bestimmt. Bei kleinen Dosen (0,125–0,25 kg ha^{-1}) geschah die Translokation in die Rhizomen zwischen 6 und 48 Stunden nach der Spritzung. Als Fluazifop-butyl in Dosen von 0,125–1 kg ha^{-1} eingesetzt wurde, hatten wenigstens 90% der Rhizomknospen binnen 72 Stunden nach der Spritzung eine lethale Dose akkumuliert. In einem anderen Versuch mit einer Dose von 0,25 kg ha^{-1}, waren 31, 72 und 92% der Rhizomknospen nicht keimfähig, als Stichproben 2 bzw. 24 und 48 Stunden nach der Spritzung entnommen wurden. Mit einer Dose von 1 kg ha^{-1} hatten alle Knospen 48 Stunden nach der Spritzung genug Herbizid akkumuliert, um die Keimung zu verhindern.

Introduction

Elymus repens (L.) Gould is one of the most troublesome perennial grass weeds in the temperate zone of the northern hemisphere. It is clear from numerous studies, that kill of all rhizome buds is essential if the weed is to be controlled. With the possible exception of alloxydim sodium (Knott, 1980; Slater & Hirst, 1980) and sethoxydim (Ingram *et al.*, 1980), most herbicides which have been used against this weed either suffer from lack of appropriate selectivity, or are unreliable in control unless large doses are used.

Fluazifop-butyl is a new post-emergence, systemic herbicide which is being developed for the selective control of annual and perennial grass weeds, primarily in broad-leaved crops. The chemical, physical and toxicological properties of the chemical have been described by Plowman, Stonebridge & Hawtree (1980). Finney & Sutton (1980) and Stonebridge (1981) have discussed some aspects of its field performance. Highly promising experimental results have been obtained for the control of many perennial grasses including *E. repens* and *Sorghum halepense* (L.) Pers., (Gibbard, Smith & Stoddart, 1982; Knott, 1982; Sarpe *et al.*, 1982; Siddall & Cousins, 1982).

The primary objective of this work was to investigate the activity of fluazifop-butyl against *E. repens*. Studies were mostly aimed at evaluating the kill of rhizome buds and determining the minimum length of time required for a lethal quantity of the foliage-applied herbicide to reach the rhizome system.

Materials and methods

Rhizomes of *E. repens* were obtained from one clone which is maintained at the Penyffridd Field Station in Bangor, Gwynedd. The rhizomes were cut into 25–30 mm long fragments usually containing a single node. These were then planted in 42 × 30 × 4 cm deep, flat plastic trays containing washed quarry sand and covered by *c.* 1 cm depth of John Innes No. 1 compost. After emergence of new shoots, plants were selected for uniformity and transplanted singly into 9·5 cm diameter plastic pots filled with John Innes No. 1 compost. All work was done in a glasshouse where the temperature varied between 18 and 22°C and the humidity was usually above 60%. The photoperiod was a minimum of 16 h maintained by supplementing natural daylight with 400-watt mercury vapour lamps. Plants were watered as required daily. At the beginning of each experiment, plants of uniform size and age were selected, sprayed in isolation and returned to the bench. An Oxford Precision Sprayer, fitted with an Allman No. 0 nozzle, was used for spraying at a pressure of 2·25 kg cm^{-2}. All spray applications were done at a volume rate of 200 l ha^{-1}. Fluazifop-butyl, commercially available as 'Fusilade', was used for the studies and all spray solutions had 'Agral 90' surfactant incorporated at 0·1% v/v in addition.

Experiment 1. Dose response; foliar v. *soil applications*

Eight to 9 week old *E. repens* plants each with new rhizomes were treated. In the first part of the study, fluazifop-butyl was used at 0, 0·25, 0·5, 1·0, 2·0 or 4·0 kg ai ha^{-1} and in the second part, at 0, 0·1, 0·2, 0·3, 0·4 or 0·5 kg ai ha^{-1}. The herbicide

was applied either as an aqueous foliar spray, when the soil was protected from spray solutions by a layer of vermiculite which was later removed, or as a soil application, when the solution was applied directly to the soil surface around the plant without wetting the base of the shoot. In the soil application, the herbicide was delivered in 2000 l ha^{-1} in order to wet the entire soil surface of each pot. Six replicates per treatment were used in the first part and eight in the second, all of which were completely randomized. Plants were observed for the development of phytotoxic symptoms and scored for foliage injury 14 days after spraying using the following scale: 0 = no injury; 1 = slight chlorosis of leaves; 2 = marked chlorosis and necrosis; 3 = severe chlorosis and necrosis; 4 = plants moribund; and 5 = plants dead. At 30 days the above-ground shoots were harvested excluding the dead material and their dry weights determined. Dry-weight data was transformed into logarithms, analysed by analysis of variance and expressed as percent reductions of untreated controls. Regrowth from the treated and untreated plants was also assessed after a further 21 days, using the following scale: 0 = no regrowth; 1 = very little regrowth with abnormality; 2 = some regrowth without abnormality; and 3 = regrowth as in controls.

Experiments 2a and b. Time required for uptake and translocation

Two experiments were conducted.

2a. Twelve week old *E. repens* plants with rhizomes having more than fifteen nodes, were sprayed with fluazifop-butyl at 0, 0·125, 0·25, 0·5 or 1·0 kg ai ha^{-1}. One, 7, 14, 21 and 28 days after spraying, the shoots of both treated and untreated plants were harvested by clipping at soil level and their dry weights determined. Out of six replicates, three were allowed to produce regrowth for a further 28 days from each individual clipping, after which it was harvested, dried and weighed. The remaining three replicates were used for rhizome-bud viability studies at each harvest time. The rhizome systems were washed free of soil and mapped to indicate the position of each bud in relation to the parent shoot. They were then cut into fragments *c.* 20–30 mm long, consecutively numbered, planted in 42 × 30 × 4 cm deep flat plastic trays containing washed quarry sand and covered by *c.* 1 cm depth of John Innes No 1. compost. Four weeks later the segments were removed from the soil and examined for signs of bud viability. Buds that had produced a new shoot or were beginning to grow were regarded as viable and others as dead.

2b. Eight week old *E. repens* plants were sprayed with fluazifop-butyl at 0, 0·125 or 0·25 kg ai ha^{-1}. The shoots of treated and untreated control plants were clipped at soil level 2, 6, 8, 12, 24, 48 or 72 h after spraying. Regrowth which developed during the subsequent 4 weeks was harvested, dried and weighed. There were eight replicates per treatment.

Plants in both experiments were completely randomized. In experiment 2a, the shoot dry weights, regrowth dry weights and percent bud viability data were subjected to analysis of variance after transformation to logarithms or arc sin %. In 2b, regrowth dry weights were transformed to logarithms, analysed and then expressed as percent of untreated controls.

Experiments 3a and b. Kill of rhizome buds

Two experiments were conducted to evaluate the potential of fluazifop-butyl to kill rhizome buds of *E. repens*.

3a. Twelve week old plants having more than fifteen nodes on the main rhizome, were selected and sprayed with herbicide doses of 0, 0·125, 0·25, 0·5 or 1·0 kg ai ha^{-1}. A minimum of fifteen replicate plants were sprayed in each treatment. At the time of spraying the soil surface was covered with vermiculite which was removed later. Plants were arranged in a completely randomized design on the glasshouse bench. Rhizomes of sprayed and control plants were harvested 3 days later. From the replicates of each treatment, rhizomes having at least twenty buds were selected. Usually the rhizome selected was the main one, except in a few pots from which two rhizomes were taken. These were cut into segments each *c.* 20–30 mm long and planted in trays as previously described. Maps were drawn to indicate the original position of each segment. Four weeks after planting, the numbers of viable buds were recorded.

3b. This experiment was similar to 3a except that only two herbicide doses, namely 0·25 or 1·0 kg ha^{-1} were used and *E. repens* rhizomes were harvested 2, 4, 8, 24, 48 and 72 h after spraying. There were seven replicate plants per treatment from which the main rhizome was harvested. Small rhizomes which did not exceed more than

two or three nodes were disregarded. Rhizomes of untreated plants were also harvested to serve as controls. The number of viable buds were counted 4 weeks later. The experimental design was randomized blocks with time of harvest as the main plots and herbicide doses as sub-plots.

Results

Experiment 1. Dose response; foliar v. *soil applications*

Foliar applications of 2·0 and 4·0 kg ha^{-1} scorched the leaves within 24 h of spraying and within 1 week all plants were dead. Soil applications of these two doses also produced severe phytotoxicity within a few days, and most plants were dead after 14 days. At lower doses, visual symptoms did not appear until 5–6 days after foliage application although growth had ceased within 48 h. The first symptom to appear was slight chlorosis of the youngest leaves which then spread gradually to all leaves. Necrosis and senescence followed. With the lower doses applied through the soil, symptoms were similar except that they developed more slowly. Soil-applied doses of less than 0·3 kg ha^{-1} caused abnormal tillering of the parent shoot, both from nodes at the base and from upper nodes. These tillers were severely distorted and had diminutive leaves. A high degree of leaf trapping was also evident.

Table 1 Effect of foliar and soil applications of fluazifop-butyl on *E. repens*

Type of application and herbicide dose (kg ai ha^{-1})		% reduction in shoot dry weight*	Foliage injury score†	Regrowth score‡
Foliar	0	0e	0	3
	0·25	76·3b	3	1
	0·5	78·6b	3	0
	1·0	90·7a	4	0
	2·0	100·0	5	0
	4·0	100·0	5	0
Soil	0	0e	0	3
	0·25	31·7d	2	2
	0·5	66·1c	2	1
	1·0	87·6b	4	0
	2·0	100·0	5	0
	4·0	100·0	5	0

At 14 (†), 30 (*) and 51 (‡) days after spraying. Zero values have been excluded from analysis. Values followed by the same letter are not significantly different at 5% level of probability, according to Duncan's multiple range test. Foliage injury scores: 0 = no injury; 5 = plants dead. Regrowth score: 0 = no regrowth; 3 = regrowth as in controls. Means of six replicates.

Table 2 Effect of foliar and soil applications of fluazifop-butyl on *E. repens*

Type of application and herbicide dose (kg ai ha^{-1})		% reduction in shoot dry weight*	Foliage injury score†	Regrowth score‡
Foliar	0	0g	0	3
	0·05	65·1cd	2	2
	0·1	70·5c	2	1
	0·2	72·3c	3	0
	0·3	82·0b	3	0
	0·4	83·2b	3	0
	0·5	87·6a	3	0
Soil	0	0g	0	3
	0·05	2·4g	1	3
	0·1	21·7f	1	3
	0·2	35·2e	2	1
	0·3	37·6e	2	1
	0·4	62·5d	2	1
	0·5	68·3cd	2	1

At 14 (†), 30 (*) and 51 (‡) days after spraying. Values followed by the same letter are not significantly different at 5% level of probability, according to Duncan's multiple range test. Foliage injury scores: 0 = no injury; 5 = plants dead. Regrowth score: 0 = no regrowth; 3 = regrowth as in controls. Means of eight replicates.

Foliar sprays of fluazifop-butyl, at doses above 0·25 kg ha^{-1} caused at least a 75% reduction in growth of *E. repens* aerial shoots (Tables 1 and 2). Doses above 1·0 kg ha^{-1} suppressed growth by more than 90%. Foliage injury scores also show severe phytotoxic symptoms resulting from spraying with doses above 0·25 kg ha^{-1}. There was no significant regrowth at all from any of the plants sprayed with such doses. Soil application of doses above 1·0 kg ha^{-1} also caused at least 87% growth reduction. The lower doses, however, showed considerably less activity than through the foliage, as shown by both the injury scores and growth reduction values. Some regrowth, with and without abnormality occurred from soil treatments at these lower doses, thus confirming that activity was less.

Experiments 2a and b. Time required for uptake and translocation

Shoot dry weight of *E. repens* plants was reduced by 1·0 kg ha^{-1} at 14 days from spraying and by 0·5 kg ha^{-1} at 21 days. With the two lower doses a significant reduction in shoot dry weight was seen only at 28 days after spraying (Table 3).

Table 3 The effect of foliar applications of fluazifop-butyl on the growth of shoots, regrowth and rhizome-bud kill of *E. repens*

Dose (kg ai ha^{-1})	Time of harvest (days)				
	1	7	14	21	28
	Dry weight of live shoots (g)*				
0	1·87efg	1·97cdefg	2·08bcde	2·19ab	2·35a
0·125	1·93defg	2·01bcdef	1·98cdefg	2·06bcdef	1·50h
0·25	2·08bcde	2·16abc	1·93defg	1·91defg	1·45h
0·5	1·83g	1·86fg	1·88efg	1·46h	1·17i
1·0	2·19ab	2·11bcd	1·54h	1·07ij	0·87j
Standard error of treatment means: 0·072					
	Regrowth dry weights after a further 28 days(g)†				
0	0·64a	0·72a	0·66a	0·57b	0·70a
0·125	0·29c	0	0	0	0
0·25	0·16d	0	0	0	0
0·5	0	0	0	0	0
1·0	0	0	0	0	0
Standard error of treatment means: time 0·042; dose 0·014					
	% viable rhizome buds†				
0	72b	77a	81a	75a	80a
0·125	60b	0	0	0	0
0·25	62b	0	0	0	0
0·5	45c	0	0	0	0
1·0	40c	0	0	0	0
Standard error of treatment means: time 2·2; dose 3·7					

Values followed by the same letter within a data set are not significantly different at 5% level of probability according to Duncan's multiple range test. Zero values have been excluded from analyses. Means of six(*) and three(†) replicates.

There was some regrowth from the crown of plants which had been sprayed with the two lower doses and defoliated 1 day after treatment. None of the other treatments produced any regrowth.

The bud viability study showed that there were some viable buds after fluazifop-butyl had been allowed to penetrate and translocate for 1 day with all doses. The buds that did not grow appeared normal, but all those on rhizomes of treated plants harvested at 7–28 days were soft, brownish-black in colour and the nodes displayed various degrees of decay. Buds on control plants were 70–80% viable.

Results of experiment 2b (Table 4) show that regrowth produced by plants clipped 24 h or more after treatment was considerably less than from control plants. Both doses caused further suppression of regrowth when plants were clipped at 48 h indicating that further movement of herbicide to the below-ground parts had occurred.

Table 4 The effects of fluazifop-butyl on regrowth of *E. repens* plants, treated and clipped at different time intervals

Time between application and clipping (h)	Dose (kg ai ha^{-1})	
	0·125	0·25
	Regrowth* as % of controls	
2	104·9a	92·2ab
6	107·9a	89·9ab
24	78·2b	50·1c
48	57·5c	14·6d
72	31·7cd	14·1d

* 28 days after clipping.
Values followed by the same letter are not significantly different at 5% level of probability, according to the Duncan's multiple range test. Means of eight replicates.

Experiments 3a and b. Kill of rhizome buds

In experiments 3a and b the numbers of viable buds from all treatment replicates were analysed assuming a binomial distribution of data, by fitting general linear models (Nelder & Wedderburn, 1972) for the effects of dosage, position and dose–position interaction (Table 5) and dosage, time and dose–time interaction (Table 6).

In experiment 3a, foliar applications of fluazifop-butyl at doses of 0·5 and 1·0 kg ha^{-1} gave complete bud kill in rhizomes having at least twenty buds (data not presented). Highly significant effects were found with the two lower doses for position and dose–position interaction. The two lower doses, 0·125 and 0·25 kg ha^{-1} gave a

Table 5 The effect of foliar applications of fluazifop-butyl on bud viability of rhizomes, at least twenty nodes in length

Rhizome segment position	Dose (kg ai ha^{-1})		
	0*	0·125†	0·25‡
	% Viable buds		
1 (basal)	70	33·3	0
2	70	16·6	0
3	90	16·6	6·6
4	90	0	13·3
5	90	0	0
6–15	100	0	0
16	100	16·6	0
17	40	8·3	0
18	20	0	0
19	20	0	0
20 (apical)	20	0	0

Source of variation	df	M.S.	V.R.	*P*
Dosage	2	242·82	125·21	<0·01
Position	19	4·60	2·37	<0·05
Dosage. Position (residual)	38	1·93		<0·01

Nodes separated 72 h after treatment. Means of 10 (*), 12 (†) and 15 (‡) rhizomes.

very high degree of bud kill (Table 5) although a few buds of some of these treatments did produce new shoots. However all these new shoots showed severe chlorosis and were abnormal. In the untreated control plants, fewer buds close to the base of the mother shoot and near the apical end of the rhizome developed into new shoots.

Data from experiment 3b (Table 6) show that the effect of time of rhizome harvesting was highly significant. The dose effect and the dose–time interaction were not significant. None of the buds of any replicate treated with 1·0 kg ha^{-1} was viable when separated after 48 h. A few of the buds of the low-dose treatments did produce new shoots even when separated at 72 h, but they were mostly malformed and showing varying degrees of phytotoxicity. With both doses up to 24 h, bud survival was always greatest in buds furthest away from the treated shoot. Most of the buds close to the treated shoot either did not produce new shoots or if they did, the shoots were abnormal. After 48 h however, the position was reversed with the low dose. Those buds that did develop came from nodes close to the base of the treated shoot.

Table 6 The effect of foliar applications of fluazifop-butyl on bud viability of rhizomes. Nodes separated 2, 4, 8, 24, 48, 72 and 144 h after treatment. Means of seven replicate rhizomes from seven plants.

Hours after spraying	Dose (kg ai ha^{-1}) 0·25	1·0
	% viable buds	
2	69·3*	66·7*
4	59·5*	65·4*
8	70·8*	48·8*
24	28·1*	23·9*
48	7·2†	0
72	8·8†	0
144	0	0
control (untreated) % viable buds: 79		

Source of variation	df	M.S.	V.R.	*P*
Blocks	6	4·55	1·57	N.S.
Time	6	111·30	35·20	<0·01
Dosage	1	5·30	1·68	N.S.
Time. Dosage	6	4·07	1·29	N.S.
Residual	84	3·20		

Nodes separated 2, 4, 8, 24, 48, 72 and 144 h after treatment. Means of seven replicate rhizomes from seven plants.

N.S. not significant at P=0·05.

* Nearly all buds developing shoots were from the distal end of rhizomes.

† Buds were from the proximal end of rhizomes.

Discussion

The results confirm that fluazifop-butyl can kill *E. repens*. A high degree of control was obtained by foliar applications between 0·25 and 1·0 kg ha^{-1}. The herbicide also seems to have useful activity through the soil as suggested by Plowman *et al.* (1980) although foliar sprays were consistently superior to soil treatments, in terms of total kill and speed of kill, up to 1·0 kg ha^{-1}. Fluazifop-butyl appears to arrest the growth of plants within a few days of application. However, the death of the aerial shoot is slow and may take up to 3–4 weeks depending on the dose. Application of glyphosate in sub-lethal quantities has resulted in increased tillering from basal nodes of shoots of *E. repens* (Caseley, 1972) and *Sorghum bicolor* (L.) Moench (Baur, 1979). This effect is thought to occur because of interference with the activity of the apical meristem, resulting in loss of apical dominance. The abnormal development of tillers in our studies may well have been due to a similar effect on the shoot apex.

That fluazifop-butyl is absorbed and translocated rapidly to below-ground parts is shown by the extent of reduction in regrowth when plants were clipped 24 h after being sprayed. The doses 0·5 and 1·0 kg ha^{-1} suppressed all regrowth when plants had been defoliated just 24 h after spraying (Table 3). With 0·125 and 0·25 kg ha^{-1} (Table 4) it is apparent that translocation of biologically active amounts of the herbicide to the base of the plant increased significantly between 6 and 24 h, and that further translocation occurred over the next 24 h.

Treatment with fluazifop-butyl at 0·5 and 1·0 kg ha^{-1} also reduced the viability of *E. repens* rhizome buds significantly even after 24 h (Table 3). At these doses, 100% bud kill was seen by 72 h (Exp. 3a) and at 1·0 kg ha^{-1}, none of the buds survived if uptake and translocation was permitted for 48 h (Table 6). These results show that fluazifop-butyl is readily mobile through the entire plant system. At 0·125 and 0·25 kg ha^{-1}, however, some buds remained viable even after 72 h from treatment (Table 5).

As seen in experiment 3b (Table 6) up to 24 h after spraying with both 0·25 and 1·0 kg ha^{-1} doses, the buds which had not accumulated lethal concentrations were from the distal end of the rhizome. This would be expected if there was a concentration gradient of the herbicide along the length of the rhizome and segmenting it at such an

early time may have isolated greater quantities in the more proximal node pieces. Forty-eight h after spraying the higher dose killed all buds irrespective of position, but with the lower dose treatment those buds that survived after 48 and 72 h were from the proximal regions of the rhizome. Claus & Behrens (1976) working with glyphosate and *E. repens* reported a better bud kill at the distal end of the rhizomes by 72 h, and observed that bud survival was greatest for buds close to the mother shoot. They suggested that either the proximal buds were more tolerant to glyphosate or they accumulated less herbicide. From the present studies, unless tolerance changes rapidly with time, it is possible that fluazifop-butyl is translocated as time progresses, from the proximal region of the rhizome towards the more active apex, thus reducing the amount in the proximal region when rhizomes are segmented 48 and 72 h after treatment. Alternatively, it may be that some metabolism of the active fluazifop acid occurred within 48 h.

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